Staff summary

Prepared by
Organizational Results Division
Missouri Department of Transportation

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For more information, contact:
Dave Amos at (573) 526-4316

Analysis of Cold In-place Recycled Asphalt Pavements

A research study by Organizational Results in cooperation with the Norhwest District and the Maintenance Division

MoDOT Summary Statement

While the initial placement of CIR eliminated all surface cracks pavement deterioration, the pavements had numerous failures during the first year of service due to poor subgrade drainage. Based solely on cost, CIR could be a viable alternative to a 1" asphalt-leveling course as a means of rehabilitating lower volume routes in Missouri where subgrade and drainage are not an issue.

Background

Like many state DOT's, MoDOT is facing pressure to do more with less and deliver the best value for every tax dollar spent. Due to the fact that flexible pavements deteriorate with time; MoDOT spends millions of dollars annually on asphalt pavement maintenance. A Hot-Mix Asphalt (HMA) overlay is often placed to extend the service life of asphalt pavements. With the continuing rise in the price of oil, a cheaper means of rehabilitation would be beneficial. Cold In-Place Recycled (CIR) asphalt overlay could provide an economical alternative.

For several decades, CIR has been used nationwide and is considered a cost-effective alternative to more common methods of rehabilitating asphalt roadways. CIR has also evolved into a continuous train operation. This train operation consists of the following equipment:

- A powerful milling machine that can cut full or partial depth and full lane width in a single pass,
- A screening/crushing machine,
- A continuous flow pug-mill mixer,
- A conventional hot-mix paver, and
- Heavy rollers to compact the mixture on the roadway.

Figure 1 – Paving train

Background *(cont'd.)*

CIR has several advantages that add to its viability as a product for pavement rehabilitation. One of these benefits is the elimination of reflective cracking. CIR eliminates this problem by pulverizing the asphalt pavement surface, which destroys the old crack pattern found in the layer being recycled. The asphalt roadway on Routes E and H exhibited signs of rutting as well as heavy cracking in both the longitudinal and transverse directions and high severity fatigue cracking.

Other attributes include:
- Strength of the material,
- Durability of the material,
- Lower cost, usually 25 to 50 percent cheaper,
- No additional cash layout for aggregate,
- Environmentally friendly – Reclaimed material is used on the roadway and not taken to a landfill, and
- Less inconvenience to the traveling public.

Technical Approach

In July 2008, MoDOT contracted with SEM Materials to test Cold In-place Recycled asphalt (CIR) on a section of Route E and H in Gentry County. The treatment eliminates reflective cracking, encourages the recycling of construction material, appears to have the equivalent strength and durability of a hot mix overlay and is a less expensive alternative per mile for the life span it offers. Both routes are 21' wide asphalt roads with grass shoulders. The average daily traffic count on both of these routes is fewer than 300 vehicles per day. Since the area is mainly used for agriculture, the traffic generally consists of farm implements and grain trucks. The areas of Route H and Route E are hilly, and the roadway has several curves. The original asphalt roadways for both routes have been treated to several cold mix overlays and numerous maintenance patches.

The CIR project in Gentry County was set up to close the routes, except to local traffic, and use MoDOT personnel to perform traffic control. A chip seal would be applied after the CIR had been placed. SEM Materials was the prime contractor on the project, while Brown and Brown, Inc. performed the CIR operations. SEM Materials also supplied the asphalt emulsion used in the CIR process and the asphalt emulsion used in the chip seal. See Table 1 for roadway dimensions and cost estimates.

Prior to the overlay operations, Dynamic Cone Penetrometer testing was performed to determine if the subgrade would support the loading of the necessary construction equipment. Cores were taken from the roadway to determine the mix design to be used on the project. During the paving operations, SEM Materials performed all Quality Control (QC) testing. Approximately two weeks prior to the start of the project, Organizational Results' personnel set up 18-500' sections (12 on Route H and six on Route E). Half of the test sections were in the northbound lane and half were in the southbound lane. A visual distress survey and rut depth measurements were taken for each test section. These sections

Table 1 – Roadway Dimensions and Cost Estimates

Location	Length of Route to be treated	Width of Roadway	Depth of CIR asphalt overlay	Estimated cost per lane mile
Route E	5.77 miles	21 feet	2 inches	$41,045
Route H	14.49 miles	21 feet	3 inches	$46,147

Technical Approach *(cont'd.)*

marked for future reference and were used for follow-up testing after the project was completed. Rut depth measurements were taken in both the left wheel path and the right wheel path and measured to the nearest one-eighth inch. Fatigue cracking was measured in square feet and the severity level was also recorded. Fatigue cracking severity levels are:

- Low-area with only a few connected cracks,
- Moderate - an area of interconnected cracks forming a complete pattern, and
- High - an area of moderately or severely spalled interconnected cracks forming a complete pattern.

The mix design submitted by SEM Materials specified that 1.5 percent asphalt emulsion would be added to the recycled asphalt. It was decided that lime slurry would not be used on this project.

The paving train used on the project consisted of an oil tanker truck connected to a Caterpillar PR-1000 Pavement Profiler *(Figure 1)*. The train logistics were as follows: The oil tanker truck supplied the pug mill mixer with the asphalt emulsion and was pushed along the roadway by the milling machine. The milling machine connected to and was followed by a screening/crushing machine. The screening/crushing machine received the milled pavement from the milling machine by means of a conveyor. The screening/crushing machine then diverted oversized material into an impact crusher to further break up the asphalt matrix. The screening and crushing process continued until all of the reclaimed material had been sorted through the vibrating screens and conveyed to the pug mill mixer. The pug mill mixer was connected to the back of the screening/crushing machine. The mixer weighed the material and an on-board microprocessor continuously adjusted the flow of asphalt emulsion, water and other liquid additives to the milled material. The millings were uniformly coated for maximum long-term cohesion and surface strength before the recycled material was placed on a conveyor to flow into the conventional hot-mix paver. A Cedarapids rubber track paver was equipped with automatic screed controls that spread the recycled asphalt to the specified depth and width. Finally, two rollers followed the paving train. The first roller was a 30-ton seven-wheel pneumatic tire roller, followed by a Cat 3116T double drum vibratory roller.

On Monday, July 21, 2008, the roadway was closed to traffic and the CIR operations began. The milling and paving operations began on the south end of the northbound lane of Route H. The contractor used a motor grader to cut the dirt and grass shoulder away from the pavement, thus eliminating the chance of foreign material contaminating the milled material. During the CIR project, SEM Materials' personnel performed all of the materials testing, except for the density tests, which were performed by MoDOT personnel. On Monday, August 25, 2008 the CIR asphalt overlay project was complete.

Two weeks after the completion of the CIR project, MoDOT maintenance personnel applied a chip seal over the CIR asphalt overlay sections. SEM Materials supplied the 45,000 gallons of CRS-2 asphalt emulsion and Buildex, Inc. supplied the Haydite aggregate. The total cost of the chip seal for both routes was $103,850.

Results and Discussion

The CIR project in Gentry Co. has been open to the traffic for more than one year. Immediately after construction, the comments from the traveling public were quite favorable. However, within five weeks after the routes were opened to traffic, the first of many failures in the road surface began to appear. Areas of fatigue cracking were first noticed before the surface began to break up and the underlying subgrade worked its way to the surface. The subgrade turned out to be wet clay.

Results and Discussion *(cont'd.)*

Maintenance crews tried to repair these failures by removing the failed area down to a depth of approximately two feet ***(Figure 2)***. Once the wet clay subgrade was removed, crushed limestone was placed in the hole and compacted before a cold-mix asphalt patch was placed. The early failures were sporadic at first, but became more numerous as time passed. All of the failed areas were outside of the test sections that were set up prior to construction.

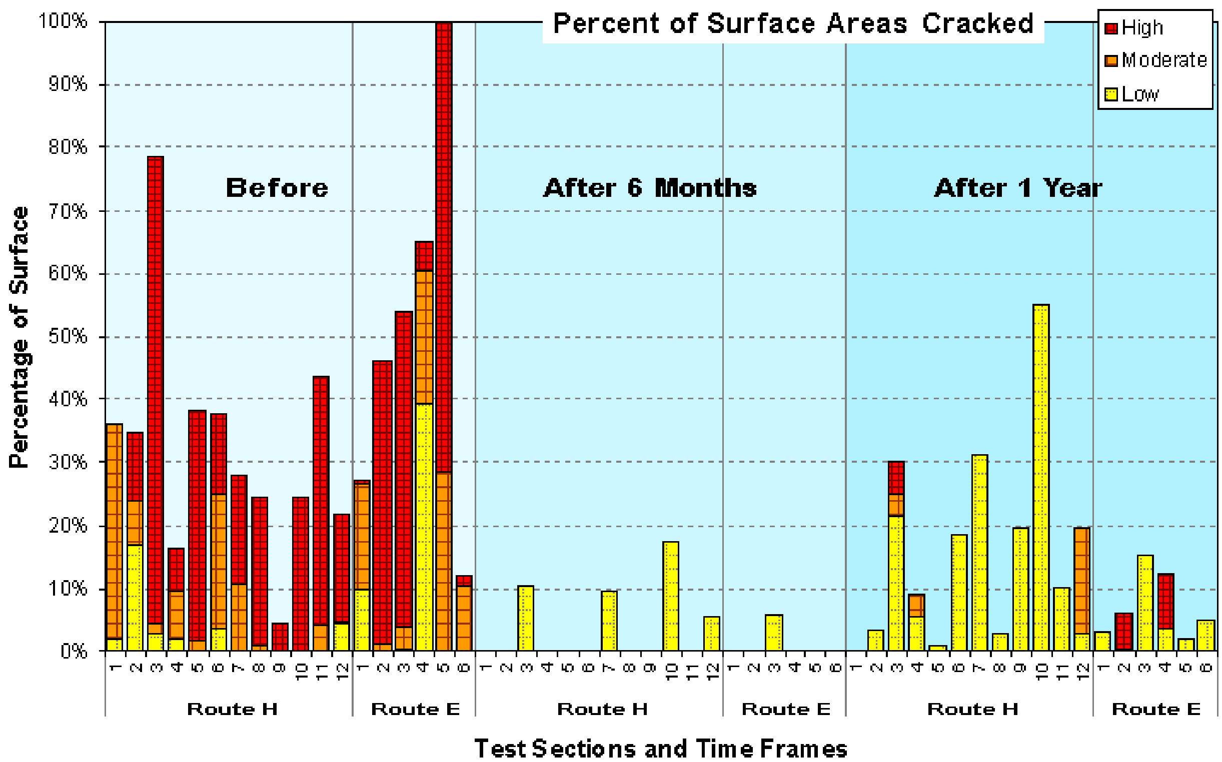
Figure 3 – Pavement rutting

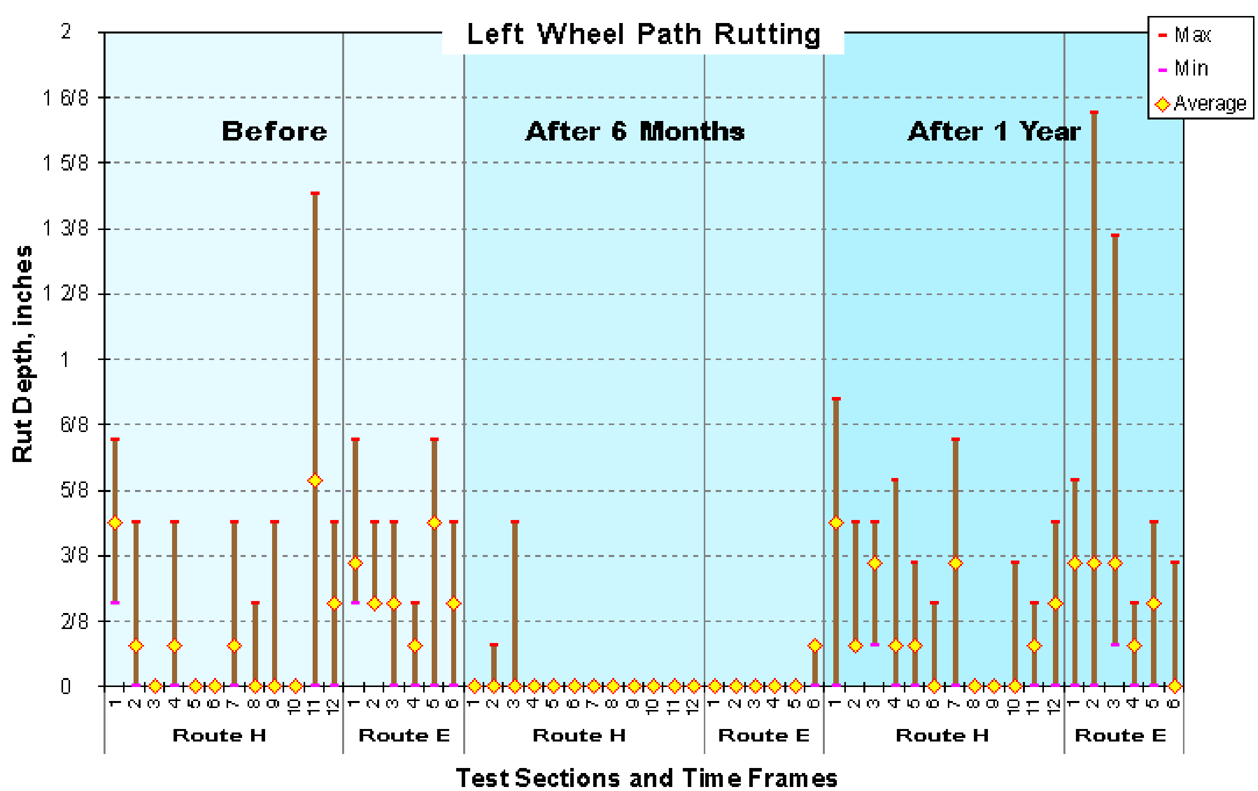
The rutting and fatigue cracking that was so prevalent throughout the test sections prior to construction were eliminated with the CIR placement. After 6 months of service, there was no evidence of rutting in any of the test sections and only a small amount of low severity fatigue cracking was found. Rutting in the test sections did appear during the one-year survey and was

Figure 2 – Maintenance repairs

almost identical to the severity that was recorded prior to construction. The fatigue cracking wasn't as severe as it was prior to construction, but the areas of fatigue cracking did increase dramatically when compared to the six-month visual distress survey.

As the patching and repairs became more frequent during the summer months, it was decided that a 1-¼" hot mix overlay should be placed on the CIR. The overlay was placed in October 2009.


Percent of Surface Areas Cracked
High
Moderate
Low
Before
After 6 Months
After 1 Year
Percentage of Surface
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Route H
Route E
Route H
Route E
Route H
Route E
Test Sections and Time Frames


Left Wheel Path Rutting
Max
Min
Average
Before
After 6 Months
After 1 Year
Rut Depth, inches
2
1 6/8
1 5/8
1 3/8
1 2/8
1
6/8
5/8
3/8
2/8
0
Route H
Route E
Route H
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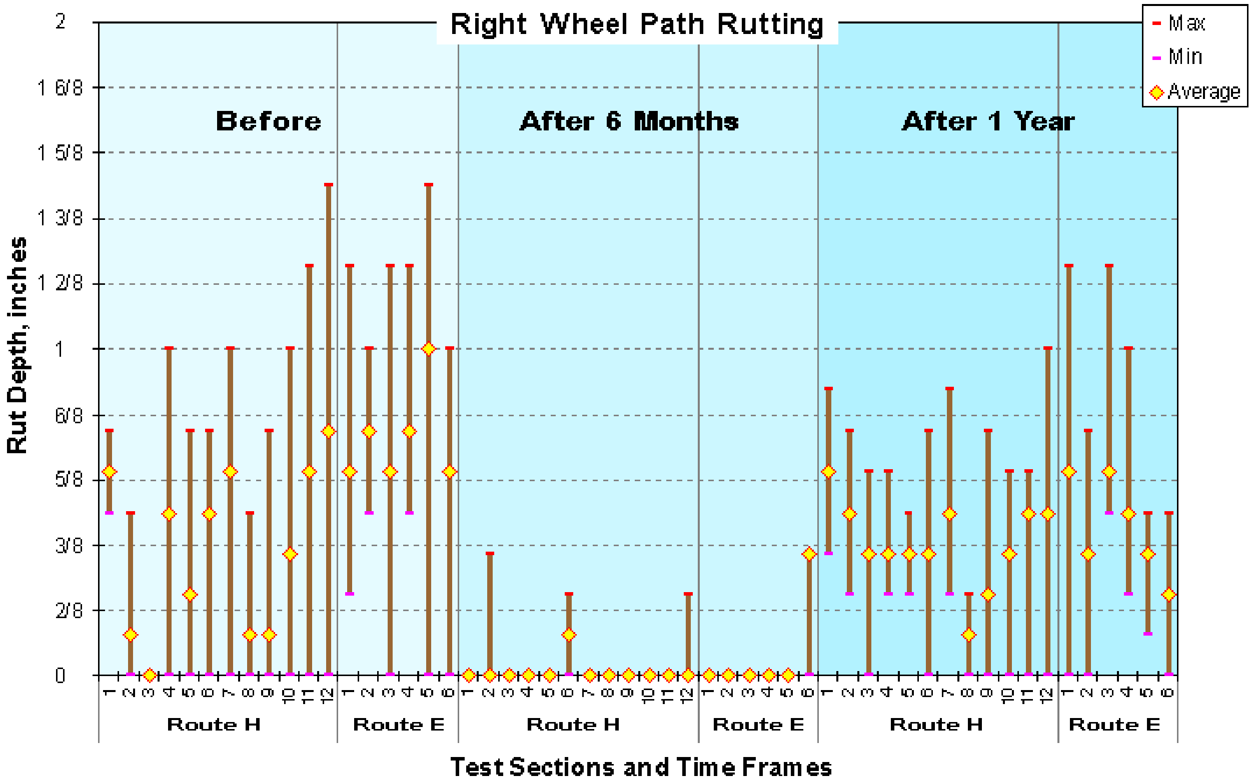
Route E
Test Sections and Time Frames


Right Wheel Path Rutting
Max
Min
Average
Before
After 6 Months
After 1 Year
Rut Depth, inches
2
1 6/8
1 5/8
1 3/8
1 2/8
1
6/8
5/8
3/8
2/8
0
Route H
Route E
Route H
Route E
Route H
Route E
Test Sections and Time Frames